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Bioremediation of Chlorinated Solvents Consortium

RTDF
Remediation Technologies Development Forum

RTDF Action Teams

Bioremediation Consortium

Lasagna™ Partnership

Permeable Barriers Action Team

Sediments Remediation Action Team

IINERT Soil-Metals Action Team

What is the Bioremediation Consortium?

The Bioremediation of Chlorinated Solvents Consortium is one of five Action Teams of the Remediation Technologies Development Forum (RTDF). The RTDF was created in 1992 by the U.S. Environmental Protection Agency (EPA) to foster collaboration between the public and private sectors in developing innovative solutions to solve complex hazardous waste problems of mutual concern. The Bioremediation Consortium was established in May 1993, when representatives from various companies, universities, the EPA, the Department of Defense (DOD), and the Department of Energy (DOE) met to discuss their shared interest in developing *in-situ* bioremediation technologies to degrade chlorinated solvents in soils and groundwater. Since that first meeting, the industrial partners of the Bioremediation Consortium—DuPont, Dow, General Electric, Monsanto, Zeneca, and Ciba-Geigy—signed a research agreement in September 1994. Agreements were then negotiated with EPA, the Air Force, and DOE to facilitate collaboration between the public and private sectors on the planned research projects. Two additional companies, Beak International and ICI Americas, joined the Bioremediation Consortium in Spring 1996.

Shortly after the Consortium was formed, they began developing a comprehensive research plan to test and evaluate the effectiveness of three complimentary *in-situ* bioremediation processes for degrading chlorinated solvents—intrinsic bioremediation, accelerated anaerobic degradation, and cometabolic bioventing. The Bioremediation Consortium initiated three Phase I field tests at Dover Air Force Base (AFB) in Dover, Delaware, in early 1995. Planning is underway to conduct Phase II field studies for each of the three processes at another site.

What is the Problem of Concern?

Chlorinated solvents are among the most common contaminants resulting from industrial and government operations. Used as solvents and degreasers, they are typically found in the soils and groundwater adjacent to manufacturing, maintenance, and service installations around the world. Although complete degradation of chlorinated solvents to harmless end products is known to occur, a better understanding of how to predict and manage these degradation processes is needed to ensure their use as cost-effective, practical solutions.

What is the Mission of the Bioremediation Consortium?

The mission of the RTDF Bioremediation Consortium is to accelerate the development of the most cost-effective *in-situ* bioremediation processes for degrading chlorinated solvents. To accomplish this mission, each of the

Consortium members jointly participate in the research, development, demonstration, and evaluation efforts necessary ***to achieve public and regulatory acceptance of these biological processes***. Consortium members contribute personnel, equipment, laboratory facilities, and funding needed to complete the Consortium's research, development, and demonstration mission. This unprecedented collaboration encourages the validation of these innovative bioremediation processes by the regulatory agencies to allow their implementation nationwide. In addition, the data generated and experience gained by the Consortium in conducting these field studies will be used to develop guidelines for using these technologies at other contaminated sites.

What Processes will be Studied?

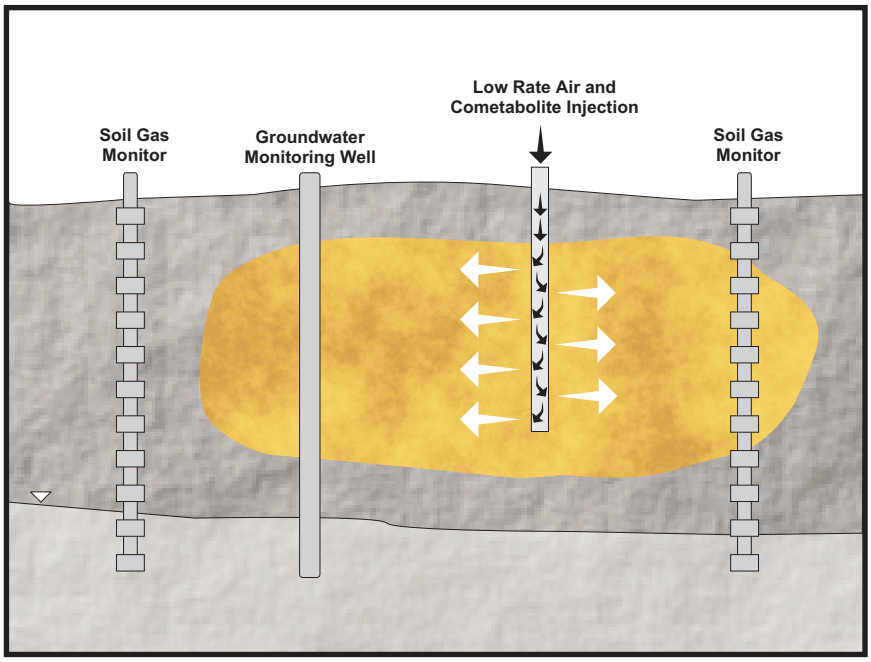
The Consortium focuses on three *in-situ* bioremediation processes: cometabolic bioventing, (for treatment in the vadose zone), intrinsic bioremediation (for treatment of the bulk of a plume), and accelerated anaerobic biodegradation (for treatment of more concentrated areas of a plume).

Cometabolic Bioventing. Laboratory studies have shown that aerobic degradation of trichloroethene (TCE) in soils occurs most easily in the presence of a cometabolite, such as toluene, propane, or methane. Cometabolic bioventing uses a technique, similar to methods currently used in bioventing technology, to efficiently deliver oxygen and a cometabolite to the vadose zone in order to remediate TCE. This technology appears to have great promise. The objective of the RTDF cometabolic bioventing study is to develop a cost-effective process that promotes the cometabolic bioremediation of TCE and other chlorinated solvents. The Consortium initiated the Phase I Cometabolic Bioventing Study at Dover AFB, where TCE is present in sandy soil.

Intrinsic Bioremediation. Intrinsic bioremediation, or natural attenuation, of chlorinated solvents in groundwater can occur at sites where indigenous microbial populations are present that can degrade these chemicals. Certain microorganisms are capable of detoxifying chlorinated methanes, ethylenes, ethanes, and aromatics by reductive dehalogenation or by oxidation. These processes can result in complete biodegradation to innocuous end products. The objective of the natural attenuation research effort is to quantitatively determine where, at what rate, and under what conditions natural attenuation occurs. Data from both field and laboratory studies will be used to develop a predictive natural attenuation model that will relate the measured degradation rates to the expected time course and outcome of intrinsic bioremediation. The Consortium initiated the Phase I Intrinsic Bioremediation Study at Dover AFB, where chloroethenes are present in shallow groundwater. Key to selection of Dover AFB as the test site was the presence of an active microbial population, which was evidenced by the detection of degradation products at the site.

Accelerated Anaerobic Biodegradation. The rate of *in-situ* anaerobic dechlorination is typically limited by the availability of food and nutrients for microbial growth. The purpose of the accelerated anaerobic degradation study is to discover what these nutritional limitations are and how to effectively deliver nutritional additions to the aquifer in order to facilitate the use of this technology at other sites. This study will also aim to: determine which electron donors and acceptors best support anaerobic bioremediation; optimize the chlorocarbon destruction rate; determine what factors control the degradation kinetics; and gather cost and performance data. The Bioremediation Consortium has begun a Phase I field study to test the accelerated anaerobic process at Dover AFB.

Cometabolic Bioventing



The three technologies under investigation are environmentally friendly–these *in-situ* processes cause minimal disturbance to the site, requiring few surface structures. They also offer the benefit of reducing remediation costs over the conventional method of pumping and treating.

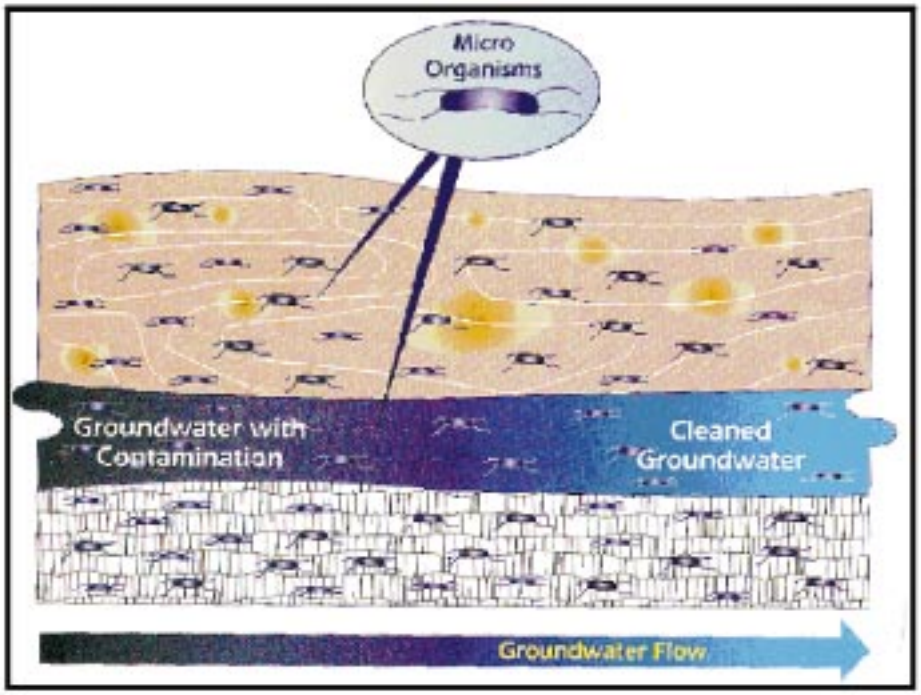
What Are the Consortium Members' Roles?

Every Consortium member plays a specific role in the collaborative research efforts for the three bioremediation processes. Each organization brings particular knowledge and expertise, as well as the laboratory research, field studies, and resources necessary to conduct the projects and evaluate the effectiveness of the technologies.

The companies are sharing proprietary information, patented technologies, and their collective understanding and experience in bioremediation mechanisms and kinetics, hydrogeology, and nutrient delivery systems to support the development and testing of the three bioremediation processes.

EPA's National Risk Management Research Laboratory (NRMRL) in Cincinnati, Ohio, is applying its knowledge and experience in developing bioventing processes to support the laboratory and field testing efforts for the cometabolic bioventing study. Under a contract to EPA, The Scientific Consulting Group provides technical and logistical support to the Consortium. The Air Force brings its experience in bioremediation and bioventing, as well as support for site characterization and field work at Dover AFB. DOE is applying its substantial bioremediation expertise and laboratory experience, as well as tools for microbial characterization, to support these studies.

Intrinsic Bioremediation and Accelerated Anaerobic Biodegradation



What Activities Have Been Completed?

The three technologies have been identified as the remediation methods of choice in the Record of Decision (ROD) for the specific sites at Dover AFB. Data from the first year of the Phase I field and laboratory studies are being analyzed by Consortium members. Extensive geological and hydrological characterization efforts have been completed to provide significant insight into the subsurface conditions. Initial laboratory biodegradation studies in batch, column, fed batch, and differential soil bioreactors have been completed for each technology. Microbial characterization efforts also have been initiated to determine the nature of the indigenous microorganisms responsible for degrading chlorinated solvents at the site. A number of characterization techniques, such as Most Probable Number (MPN), direct count, Phospholipid Fatty Acid Analysis (PLFA), and molecular approaches (16s RNA) have been employed to this end. The Consortium also initiated modeling efforts to develop a tool that will help predict the performance of each of the bioremediation processes at other sites.

In addition, the Consortium is collaborating with the Western Governors Association's (WGA) Interstate Technology and Regulatory Cooperation (ITRC) subgroup. The WGA/ITRC will assist with the development and validation of protocols for each of the three technologies, which will facilitate the transfer of these biological processes to other sites.

What Activities Are Planned?

Research efforts on the three Phase I projects will continue until 1998. The Strother Field Industrial Park site in Winfield, Kansas, has been selected for the Phase II Accelerated Anaerobic Biodegradation Study and the Phase II Intrinsic Bioremediation Study. Complementary efforts will be undertaken to validate the conclusions drawn from Phase I. The Consortium is currently analyzing characterization data on Hill AFB to determine if that site is appropriate for the Phase II Cometabolic Bioventing study.

What are the Funding Sources?

EPA provides the necessary funds and staff to support and facilitate Bioremediation Consortium meetings, as well as meetings of the other RTDF Action Teams. Staffing, funding, and equipment needed to develop and test the three bioremediation processes are being provided by the Bioremediation Consortium members. Both EPA and the Air Force work through a Cooperative Research and Development Agreement, which allows government agencies to work with industry on collaborative research efforts. DOE has contributed significant funding for the intrinsic bioremediation and accelerated anaerobic biodegradation Phase I projects. The Phase I cometabolic bioventing field study has been primarily funded by EPA, the Air Force, and Zeneca.

Who Are the Consortium Members?

Beak International
Ciba-Geigy Corporation
Dow Chemical Company
DuPont
General Electric
ICI Americas
Monsanto Company
Zeneca, Inc.

U.S. Air Force
U.S. Department of Energy
U.S. Environmental Protection Agency

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RTDF
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Would You Like More Information?

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